

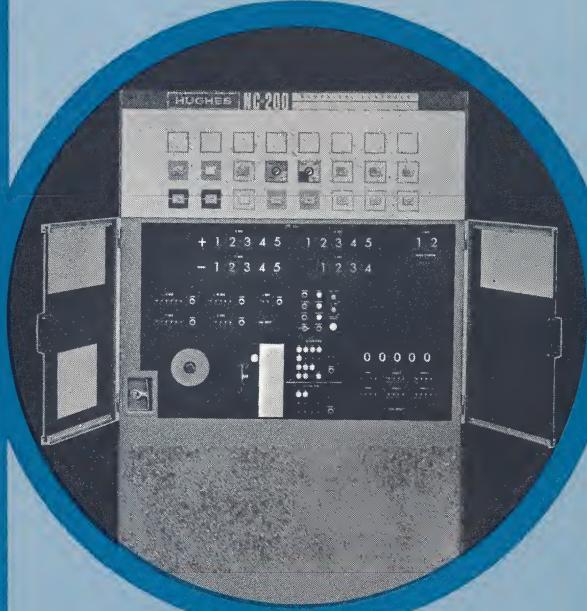
# HUGHES NUMERICAL CONTROLS



an  
extension of  
management  
control  
to . . .

REDUCE COSTS,  
INCREASE PRODUCTION,  
IMPROVE QUALITY . . .

WITH RELIABILITY



*Creating a new world with ELECTRONICS*

**HUGHES**

HUGHES AIRCRAFT COMPANY  
INDUSTRIAL SYSTEMS DIVISION

# HUGHES NUMERICAL CONTROLS

...are reducing production costs for industrial users for the  
**METAL-WORKING  
INDUSTRY**

... and HUGHES NC-200 Series Numerical Controls bring to industrial management an even greater tool for cost control

The thousands of metal-working machines throughout the world now being operated with numerical controls are giving their users higher production rates, improved product quality, reduced scrap, lower tooling costs, smaller product and tooling inventories, longer tool life and many other profitable advantages.

Many improvements in the field of machine tool control have been made during the few short years that numerical control has been available. Today's concept and application of numerical control has elevated metal-working machinery to a new level of automated productivity with tremendous savings to the manufacturer and his customer. Numerical control puts all operator orders on a simple punched tape: X-Y-Z axis positioning of the work and tool, tool changes, feed, speed and cycle selection.

The advantages of numerical control are expanded even further with the HUGHES NC-200 Series Numerical Controls, representing ten years of development and use by hundreds of metal-working plants:

- increased productivity
- faster programming
- simpler operation
- design compatible with nearly any production metal-working equipment and machinery requiring positioning straight cuts or punching in controlling:

DRILLING MACHINES  
HORIZONTAL BORING MILLS  
PUNCH PRESSES  
TURRET LATHES  
MILLING MACHINES

... and, these two and three axis numerical controls can also be used with spot welders, tube benders and other specialized metal-working equipment. Hughes NC-200 Series Numerical Controls require a minimum of floor space and are efficiently integrated with a wide range of types and sizes of machine tools. The real extent of these special applications and adaptations is a function of the ingenuity and vision of manufacturers... and the support of Hughes' applications engineers.

## Hughes NC-200 Series Numerical Controls ...

are now working as an efficient management tool, and are used to extend management control more effectively into the production area to reduce costs, to insure sustained product quality, and to increase production speed and volume.

### EFFICIENT PACKAGE DESIGN ...

to insure maximum operator utility, easier operation, faster maintenance and less down time, with features to permit visual check of input data, manual inputs for custom and semi-automatic operation, and other important time saving advancements.

### INCREMENTAL PROGRAMMING ...

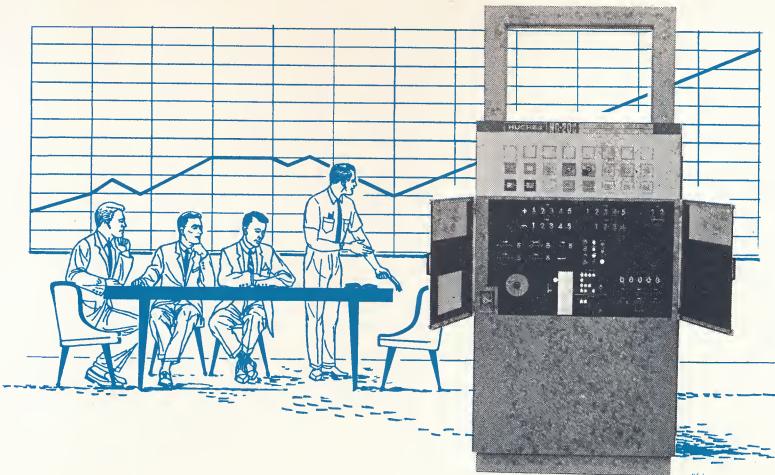
simplest and least expensive of all types of programming in use today — done from conventional engineering drawings without the need to change drafting practices, and — the only type of programming capable of using advanced digital control techniques to their fullest extent for greatest productivity.

### SOLID STATE ELECTRONICS ...

with an extra safety margin built in to eliminate extensive down-time due to component failure. The NC-200 Series Numerical Controls will operate under relatively more severe temperature and humidity conditions than machines they control ... and, without air conditioning equipment.

### FAST ORIENTATION ...

no need to teach or learn new and intricate procedures, advanced mathematics, tool set-up methods or drafting practices. Without major production interruption, the Hughes NC-200 Series Numerical Controls are placed into operation smoothly and begin producing profit dollars fast.



■ *Technical Information*  
*Hughes NC-200 Series Numerical Controls*

# HUGHES NUMERICAL CONTROLS

- SIMPLEST PROGRAMMING
- SHORTEST PROGRAMMING TAPES
- MINIMUM SERVICE AND MAINTENANCE
- EASIEST OPERATION
- COMPLETELY SELF CHECKING . . .  
*at the manuscript stage  
at the machine*

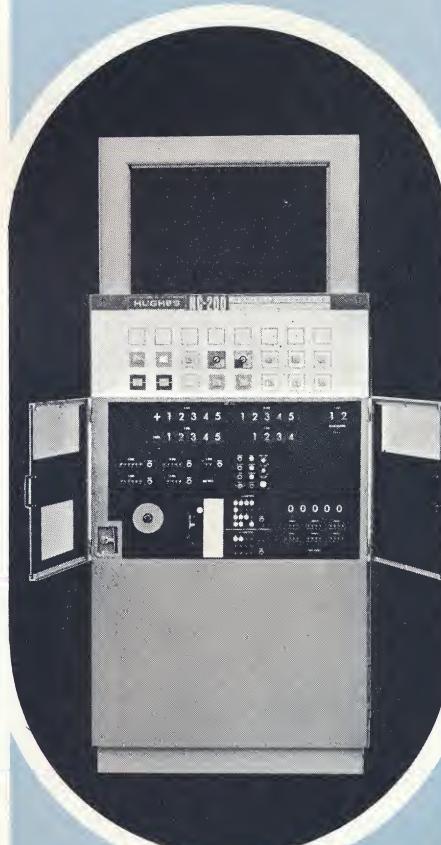
*Creating a new world with ELECTRONICS*

**HUGHES**  
HUGHES AIRCRAFT COMPANY  
INDUSTRIAL SYSTEMS DIVISION



an  
extension of  
engineering design  
control into  
production  
to ensure

**DESIGN CONFORMANCE**  
**HIGHEST PRODUCTIVITY**  
**QUALITY CONTROL**

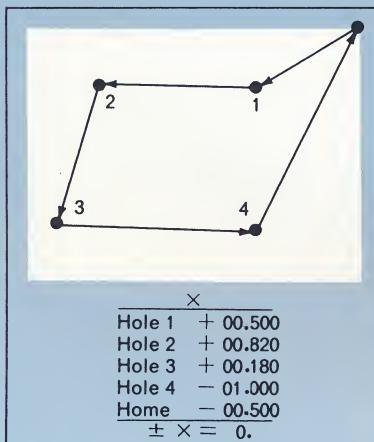


# WHY INCREMENTAL PROGRAMMING



Incremental programming cuts inspection time by 90%!

Just start and end each tape program at a fixture reference or a setup hole zeroed to the machine spindle. Indicate the reference hole — that is all the inspection needed. Since the sum of all moves equals zero, any positioning error will show up immediately.



No matter how your drawings are dimensioned, the Hughes incrementally programmed N/C system provides for easy self-checking by the "add up to zero" method. Transpositions are caught; wrong callouts prevented.

- simpler part programming — 50 to 75% less programming time
- less complex manuscript preparation
- self checking for assurance of accuracy — as much as 90% reduction of inspection times
- easy manual data insertion for changes of machine position, start point, custom variations and checking
- full floating zero

## RESULTS:

Less cost, less operational expense, less complex operation . . . and assurance that produced part reflects all the features of the engineering design.

Metal-working machinery operates incrementally — from one point to another. Logically then, the Hughes NC-200 Series Numerical Controls use **incremental** programming — point-to-point measurements — to get machine tool positioning devices from one point to another with a high degree of accuracy. Incremental programming employs digital mathematical language, the world's most widely used computation and control media. Hughes Incremental Systems do not accumulate errors.

Incremental programming is a means of planning the production of machined parts in the same manner in which the machine tool will make the parts — incrementally. The starting point is a reference point on the part or fixture selected by either the programmer during the programming stage, or by the machine operator after the part is placed on the machine tool for production. Instructions begin at this starting point (or "home"). The instructions in the program direct the process to the next point, command the corresponding operation, proceed to the next point, operate again, etc., until the part is complete to the extent of that programmed operation series. Incremental programming can end with a "return to start" command to verify that the work positioning elements return to the exact starting point, ensuring that the machine and tape operated accurately — a self checking inspection feature of the Hughes NC-200 Series Numerical Controls. Return to the same position from which it started proves the programming and machining accuracy because the algebraic sum of all incremental movements must equal 0. No other programming system has this exclusive feature.

WITH INCREMENTAL PROGRAMMING, the "return to start" means that **ALL** operations were accurate per the tape instructions. With **ABSOLUTE** programming systems, the work positioning table coming "home" **only** verifies that it has responded to a command to come "home," nothing more. Absolute-programmed numerically controlled systems depend upon an arbitrary reference point, usually external and remote from the part being produced. All dimensions are referenced back to that point during each instruction and operation. Replacing a part upon the work positioning table, and achieving exact register, is thus highly critical, time consuming, expensive and, if not exact, results in an inaccurate part. Hughes made the right choice when, over five years ago, the design engineers working on the NC-200 system decided that the **INCREMENTAL** programming concept had the greatest potential value to all future users of numerically controlled machine tools.

## HUGHES NC-200 SERIES NUMERICAL CONTROLS

### PROGRAMMING

Programming for machines using the Hughes NC-200 series controls is simple. Existing personnel with knowledge of shop practices can be trained in less than one week. Standard typewriter type tape operation equipment is used. It is not necessary to make special drawings. The programmer plans his manufacturing sequence, selects tools, and describes the part holding method. He then lists his coordinate locations for each operation on the manuscript and adds the code for proper feed, speed and machine functions. The completed manuscript is then given to a typist for preparation of tape. Average total programming time, including sequencing, manuscript writing and preparing the tape is less than three minutes per hole.

Miscellaneous or "m" functions are provided to control coolant flow, initiate special features such as fixture index, automatic clamps and to rewind tapes or delay operations for inspection or other purposes.

An example of a program illustrates the simplicity of the total operation: A complete range of preparatory or 'g' functions (see Table) are available for the programmer to define the spindle cycle (drill, mill, tap or bore) to establish the level to which the tool should retract after machining, to activate productivity-increasing functions such as free z and elimination of slow-down at the bottom of a hole. Each type of function remains active till superseded.

TABLE OF g FUNCTIONS

g-60	Top retraction	g-68	Inhibit feed - ON
g-61	Selective zero or 'r' retraction	g-69	Table retract
g-62	Surface retraction	g-80	No cycle (milling)
g-63	Inhibit creep - OFF	g-81	Drill cycle
g-64	Inhibit creep - ON	g-82	Drill w/dwell cycle
g-65	Free z - ON	g-84	Tap cycle
g-66	Free z - OFF	g-85	Bore cycle
g-67	Inhibit feed - OFF	g-89	Bore w/dwell cycle

HUGHES NC-220 SERIES PROGRAM SHEET

Sheet 1 of 1

PART NO. 150621

Operation description	Block No.	g00	X Axis x=00000	Y Axis y=00000	Z Axis z=0000	F.R. f00	W0000	R00	S.S. s00	Tool too	m00
ALL AXES HOME	0000 001	g69									
SET CYCLE	0000 002	g81									
SET RETRACT	0000 003	g62									
FREE Z ON	0000 004	g65									
DRILL 1/4 A1	0000 005	g63	X+09500	Y+06500	Z1100	f40	W08500	508	t01	m08	
DRILL 1/4 A2	0000 006	g63	X+02560								
DRILL 1/4 A3	0000 007	g60	X-01310	Y-00750							
CREEP ON	0000 008	g64									
SET RETRACT T	0000 009	g61									
FREE Z OFF	0000 010	g66									
C'BORE A1	0000 011	g82	X-01250	Y+00750	Z0280	f40	W01000	A02	t02		
C'BORE A2	0000 012	g60	X+02560								
CREEP OFF	0000 013	g63									
FREE Z ON	0000 014	g65									
DRILL 1/4 B	0000 015	g81	X-02560	Y-01325	Z1200	f40	W01000		t03		
TAP 3/8-16 B	0000 016	g84			Z1200	f14	W01000	503	t04		
SET RETRACT	0000 017	g61									
DRILL 1/4 C	0000 018	g81	X+02050	Y-00745	Z0500	f30	W00500	A03	508	t05	
DEEP HOLE	0000 019				Z0880		W01000				
DEEP HOLE	0000 020	g60			Z0300		W01380				
CREEP ON	0000 021	g64									
POS. TO MILL	0000 022	g80	X-00800	X00550	Z0125	f99	W00500		t06		
MILL SLOT	0000 023			Y+01350		f11					
MILL OFF	0000 024	g81									m07
KEY AXES HOME	0000 025	g69									m29

#### INCREMENTAL PROGRAMMING REQUIRES NO CHANGE IN STANDARD DRAFTING PRACTICES!

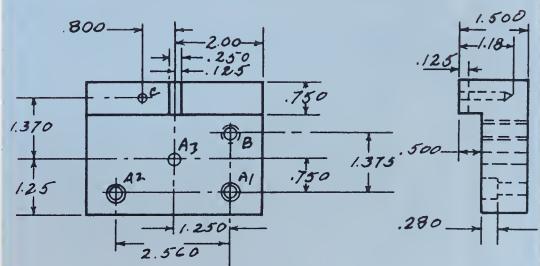
NUMERICAL CONTROL does not necessitate special dimensioning on production drawings for programming procedures. The Hughes NC-200 Series Numerical Controls use a programming manuscript prepared directly from conventional engineering drawings — no new drafting room procedures are required. Any drawing — with incremental or absolute dimensioning — of a quality and format sufficient for the production of a part by the manual method is adequate for the programmer's use in preparing a manuscript for incremental programming.

ADVANTAGES FOR SPECIAL PARTS... with incremental programming. Repetitive hole patterns — just define the coordinates for the pattern plus the move to the starting point of the next repeated pattern. The tape puncher can

either repeat the pattern as many times as necessary, or punch in a tape rewind, so that the pattern is repeated automatically. Example: A turret drilled part with 10,000 holes in a matrix pattern required only three lines of manuscript, plus three lines of typing and machine operator instructions. The tape preparation took 29 minutes. That is INCREMENTAL programming at work.

MULTIPLE SETUPS... ONCE the part is programmed, a repeat command is added along with a new start point, and another example of INCREMENTAL programming simplicity is evident.

MIRROR IMAGE PARTS... ONCE a part is programmed, simply reverse the sign of each dimension in ONE coordinate to make the mirror image program. A brief note from the programmer, on the manuscript, to the typist is all that is required to again demonstrate the simplicity and versatility of INCREMENTAL programming.



A1	DRILL 1/4 DIA THRU
A2	" " " "
C	C'BORE 2 1/4 DIA X .280 DP
A3	DRILL 1/4 DIA THRU
B	DRILL 5/16 DIA THRU
	TAP 3/8-16 NC-2B FULL THR'D
C	DRILL .125 DIA X 1.18 DP

# OPERATING CONVENIENCE and SIMPLICITY

and  
A WIDE RANGE  
OF MODELS

to satisfy a variety  
of applications . . .  
and projected costs

In 2 typical examples:

NC-221

NC-223

- **FAST TAPE LOADING . . .**  
takes less than 10 seconds — no manual engagement of sprocket holes, no takeup reel to thread or install. A punched code at the end of the tape signals the tape reader automatically to rewind the tape, or rewind can be manually selected. The Hughes high-speed photoelectric tape reader ensures longer tape life, reads at the rate of 60 rows per second. Loop tapes can be used for specialized high-production applications.

- **CONVENIENT CONTROLS . . .**  
all controls are placed on the front panel of the Hughes NC-200 Series Numerical Controls for maximum operator visibility and efficiency. Data storage information lights display all information being taken from the program tape for each row as it passes under the photo-electric tape reader, providing a simple, direct means for checking programs and trouble shooting the equipment. Provisions are available for manually dialing all information into the numerical control for semi-automatic or tape override operation.

- **"ALL STOP" CONTROL SAFETY**  
an "All Stop" button is provided to stop all movements immediately without loss of stored information in the event of emergencies. After the cause for stopping has been relieved, the command to proceed from the stopped position may be given without loss of continuity or accuracy.

- **COMPLETE CONTROL PROVISIONS . . .**  
are available for full automatic, semi-automatic, block-at-a-time and jogging operations as well as the complete control of the machine tool at the numerical control console.

*Lowest cost 2 axis control*

*3 axis, spindle control*

## OPTIONAL FEATURES —

The NC-221 and 223 models are available with a wide variety of optional features to further extend management control. These options include:

- Tool offset to permit use of random length tools or to compensate for tool wear. Simple setup, requiring only the manual movement of the machine spindle until the tool contacts the work and then the dial entry of displayed data for each tool.
- Programmed speed rates for machine spindles and feed rates for both spindles and work positioning table.
- "Magic 3" speed and feed selections to conform to NAS & EIA Specifications requirements.
- Coolant, air blast and dwell control — plus any other required on-off functions.
- Mirror image control to permit production of left-hand parts from right-hand tapes, or vice versa.
- Programmed sequence number or operation counter.
- Rotary table control to resolution of .01°.
- Feature index function control.
- Tool selection or tool change light.

## PRODUCTIVITY

The NC-200 control is built to help users realize the productivity which Numerical Control makes possible. Table positioning is fast with no overshoot or settling time. With the NC-223, full control of spindle functions is provided so that air cutting time can be almost completely eliminated and the programmer can optimize each job by the use of simple-to-use function commands. In addition to the normal "canned" cycles of drilling, tapping, boring and milling, the NC-223 provides for an easily adjustable transition point to start deceleration from traverse to feed rate. The adjustment feature allows each installation to be optimized so that this deceleration distance is the minimum required amount. Deceleration is built into the rapid approach or 'W' axis which means that the feed-rate distance is the hole depth only, not depth plus deceleration allowances. One additional productivity benefit that is derived is that the same tape can be used on machines with different deceleration distances without productivity losses.

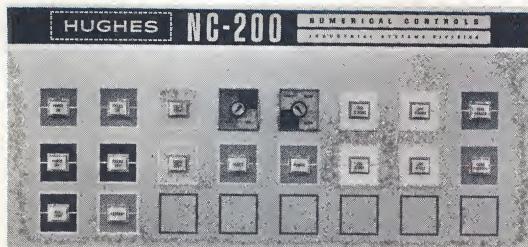
Another unique productivity feature is a programmable

function called "free z." This permits the tool to advance toward the work while the table is moving into position instead of waiting till table movements are completed. Properly used, this function will save as much as 3 to 4 seconds per hole.

In order to ensure depth accuracy by preventing overshoot, it is customary to slow down the feed rate near the bottom of a hole to a creep rate. However, when the holes being drilled are through holes or where high accuracy is not required, this slow-down requires additional cycle time.

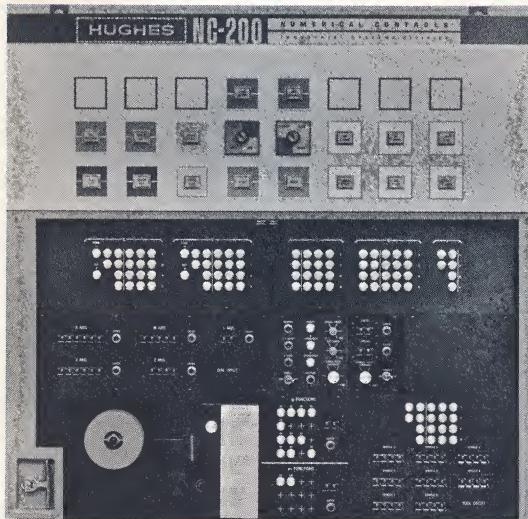
With the NC-223, the programmer can eliminate this creep and thus increase productivity.

A multiple choice of spindle retraction points is offered to minimize air cutting time. The tool can be retracted to work surface, to upper limit, or to a clearance plane. The latter is especially useful where bosses, clamps or part geometry would interfere. The clearance plane is established at a safe level and can be used at the programmer's option.



## NC-221

Simplified two-axis control, available with or without manual input. Designed to provide fast, accurate table or part positioning with cycle initiation for low cost drilling and punching machines. Has the same field proven solid state circuits and components as more complex systems. May be modified to permit application to specific types of equipment with the addition of a full range of auxiliary function controls.



## NC-223

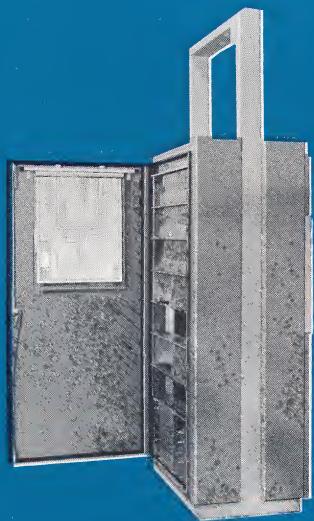
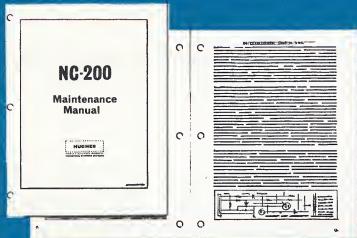
Most productive three-axis control for application to all types of equipment requiring control of a spindle axis. Available with a full range of options and auxiliary function controls, with displays and manual inputs for all controlled axes and functions. Features automatic cycles and programmable functions designed to greatly minimize air cutting time.

*NC-200 =  
an extension of  
management and engineering  
control*

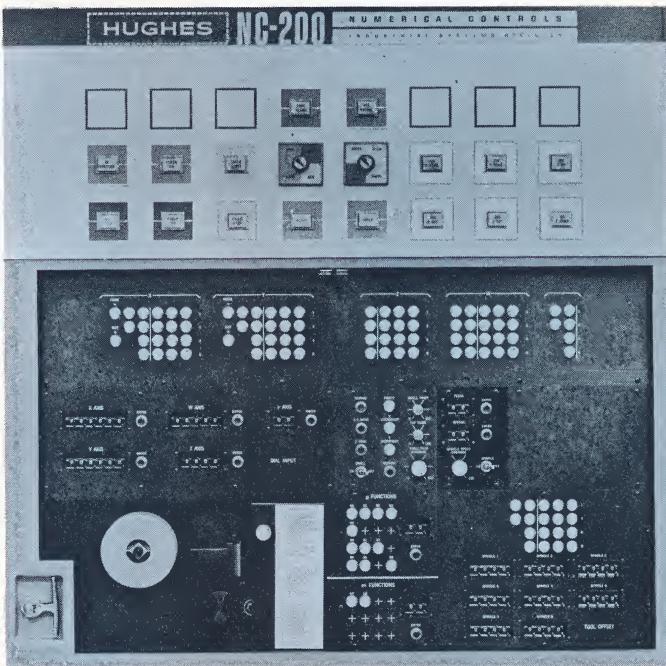
*Creating a new world with ELECTRONICS*

**HUGHES**

## EASY, FAST MAINTENANCE



*designed for quick access . . .  
less down time . . .  
more production time*



Hughes NC-200 Numerical Controls require a very minimum of maintenance — and when maintenance is required, the cabinet design ensures immediate access to any of the internal areas for fast trouble-shooting and repair.

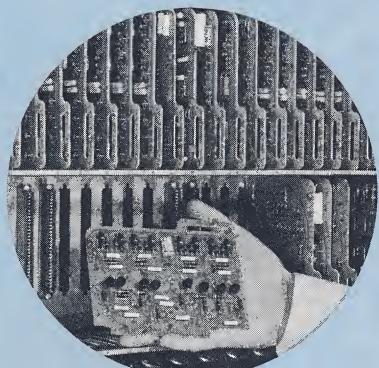
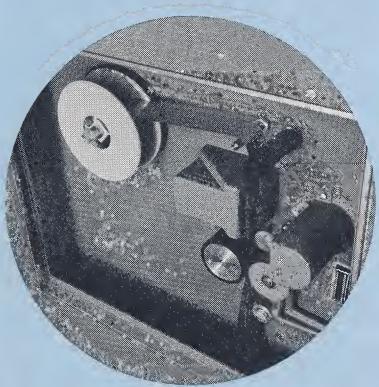
The indicator lights on the front control panel of the NC-200 Series provide an easy means of checking each operation of the equipment. Test tapes can be run through to check out every circuit and operating function of the NC-200. Also, where manual input provisions are included, these buttons can be used to check out the response of the equipment.

Additional trouble-shooting aids are provided by means of "cause and effect" tables in the Maintenance Instruction Manual furnished with each equipment. No source of trouble, no matter how elusive, should take more than a few minutes to localize.

All access doors and openings are designed to operate lightly and smoothly, and all intercabling is arranged to receive a minimum of wear and not obstruct internal parts and components.

Many of the card modules are identical and interchangeable, a feature which makes practicable "part-trading" as an extra trouble-shooting procedure.

A complete set of blueprints covering all of the functional systems of the NC-200 Series Numerical Controls is provided with each equipment and retained for convenient access on a specially designed binder inside the rear access door. Included are electronic insert schematic diagrams, and system elementary diagrams that indicate system operation and logic and also show physical location of all components.



*to make the NC-200  
the best tool for the job ...*

The Hughes photo-electric tape reader was especially designed for the Hughes NC-200 Series Numerical Controls, and efficiently satisfies every specific demand — another example of total engineering, and another exclusive feature of the NC-200.

Tape life is greatly extended with a photo-electric reader. Without brushes or contacts to wear the tape or collect dust and dirt, the tape life is nearly infinite and the possibility of mechanical damage is virtually eliminated. Also, the row-by-row reader is fail safe: it continually checks itself to make certain that reading errors do not occur.

SOLID STATE ELECTRONICS . . . are used throughout. All circuits employ highly reliable, heavily safety-margined transistors and diodes.

All circuit components have been selected for their capability to operate reliably for long periods of time under temperature and humidity conditions many times more severe than the anticipated extremes. This intentional design margin and careful component selection has resulted in a numerical control that needs no temperature compensation by air conditioners, nor is the NC-200 design encumbered economically or functionally by the need for cooling devices that serve no purpose other than to offset the inherent design shortcomings of the control system itself. With the NC-200, your dollars buy **CONTROL**.

SOLID STATE SWITCHING CIRCUITS . . . have replaced the use of relays almost entirely in the Hughes NC-200, and the few remaining relays are hermetically sealed, extra long life rated, and plug into receptacles for fast replacement. With the NC-200, your dollars buy advanced design for fast, easy maintenance.

## SPECIFICATIONS

Class .....	Position and straight cut AIA Class III
Type .....	Digital, incremental
Format .....	Word address
	Conforms to EIA Specification RS-273 and AIA Specification NAS 943
Input Medium .....	1" wide, 8-channel perforated tape
Tape Reader .....	Hughes Photo-electric
Reading Speed .....	60 rows per second
Resolution .....	0.001" (.0001 available)
Electrical Accuracy	
X & Y Axes .....	±0.0005"
Z Axis .....	±.001"
Repeatable Accuracy or Precision (Typical)	
X & Y Axes .....	±0.0002"
Z Axis .....	±0.001"
Axis Drive .....	Electrical or Hydraulic to suit machine requirements
Travel .....	Unlimited — simultaneous positioning
Speed .....	As required — up to 250 IPM
Programming Method .....	Advanced incremental
Power Requirements .....	117 volt 60 cycle
Dimensions .....	Model 223: 64" x 36" x 28"; Model 221: 57" x 30" x 19"
Weight .....	Model 223: 600 pounds; Model 221: 500 pounds

**HUGHES  
TRAINING,  
MAINTENANCE,  
SERVICE . . .  
ON THE  
NC-200 SERIES**



*Hughes training, maintenance data, and field service are designed and provided for maximum utility and service from the NC-200 Series Numerical Controls.*

**EASIEST . . .**

The functional simplicity of the NC-200, along with the comprehensive instructional information provided, makes orientation and training a pleasant experience for the purchaser and his personnel. Users of the NC-200 learn to use it fast . . . and learn to like it even faster. Average training time is approximately 40 hours for complete familiarization, instruction and final checkout.

**COMPLETE . . .**

The technical documentation package includes maintenance manuals which provide complete theory of operation and maintenance data, trouble shooting tables for average shop personnel, electrical and logic diagrams and point-to-point wiring data. Also, the Hughes Industrial Systems Division personnel in charge of training and field service remain constantly at your service to provide personal assistance should special questions arise at any time.

**PROMPT . . .**

Field service is prompt and qualified. Hughes Industrial Systems Division field representatives devote all of their time to Numerical Control sales and service. They are on call for technical consultation and aid in any unusual problem areas, and show users the way to extra benefits through the NC-200 Series Numerical Controls. These services include special instruction sessions for attendance by management, engineering, planning and shop personnel.

Inquiries regarding applications of the Hughes NC-200 System and other products of the Hughes Industrial Systems Division are invited. Qualified personnel are anxious to assist you with the simplest or the most complex application.

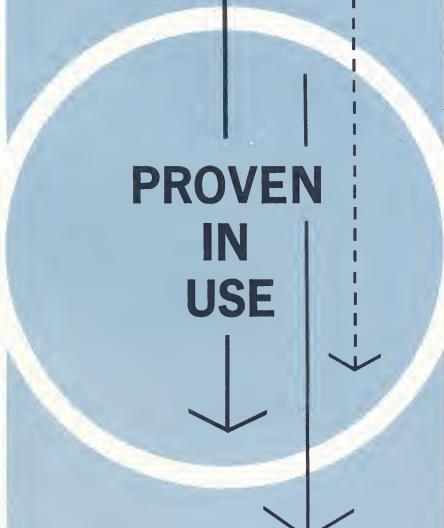
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**HUGHES**

HUGHES AIRCRAFT COMPANY

INDUSTRIAL SYSTEMS DIVISION

P.O. BOX 90904  
LOS ANGELES 9, CALIFORNIA



**PROVEN  
IN  
USE**

**PARTIAL LIST**

*.... of HUGHES NC-200  
Series Numerical Controls  
Users :*

General Dynamics/Astronautics  
San Diego, California  
Motorola  
Phoenix, Arizona  
Bras scope, Div. of  
General-Precision  
Glendale, California  
Courtesy Manufacturing  
Chicago, Illinois  
Rock Island Arsenal  
Rock Island, Illinois  
Naval Ordnance Plant  
Macon, Georgia  
McGraw Edison  
Pittsburgh, Pennsylvania  
Oshkosh Motor Truck  
Oshkosh, Wisconsin  
International Harvester  
Milwaukee, Wisconsin  
I.B.M.  
Poughkeepsie, New York  
Micro Tool and Engineering  
North Hollywood, California  
Lycoming, Division of Avco  
Stratford, Connecticut  
Perkin Elmer  
Norwalk, Connecticut  
Wood Newspaper  
Plainfield, New Jersey  
Nortronics  
Hawthorne, California  
Collins Radio  
Cedar Rapids, Iowa  
Naval Avionics Facilities  
Indianapolis, Indiana  
General Dynamics - Pomona  
Pomona, California  
McDonnell Aircraft  
St. Louis, Missouri  
U.S. Naval Shipyard  
Mare Island, California  
U.S. Naval Shipyard  
Portsmouth, N.H.  
H.P.M.  
Mt. Gilead, Ohio  
Lockheed-Sunnyvale  
Sunnyvale, California  
Lockheed-Marietta  
Marietta, Georgia  
I.B.M.  
Endicott, New York  
Baldwin-Lima-Hamilton  
Aurora, Illinois  
Tektronix  
Portland, Oregon  
Clark Bros.  
Olean, New York  
Creamery Package  
Ft. Atkinson, Wisconsin  
Caterpillar  
Peoria, Illinois  
Joy Mfg.  
Claremont, N.H.  
Union Carbide  
Paducah, Kentucky  
Aro Corp.  
Bryan, Ohio

**MAXIMUM APPLICATION . . .  
MAXIMUM COST REDUCTION . . .  
MAXIMUM PRODUCTIVITY . . .**

*with the Hughes NC-200 Series  
Numerical Controls*

The PRODUCTIVITY feature of the Hughes NC-200 Series is the most dramatic of all its many advantages. For example, the NC-200 THREE AXIS Control has been specifically designed for maximum productivity and simplicity of programming. Reports show that it is 15% more productive than any other system in controlling the spindle axis on a machine, and that the number of separate blocks in a program is reduced as much as 50%.

With the NC-223 Control, the spindle can be advanced towards the work while the table is moving to position. Other systems require that the table be in position before the spindle can advance; result . . . a time loss of as much as 3 to 4 seconds per hole. This is a programmable function called "free Z."

The NC-223 eliminates the need for adding a deceleration distance to the depth of the hole. This is customarily done to provide for transition from rapid traverse rate to feed rate, but on repeat cycles it means that this distance of 2 or 3 tenths of an inch is moved at feed rate. On the NC-223, the deceleration allowance is built into the rapid traverse or *w* axis and is adjustable for each installation and machining condition. This permits optimizing the machine and reduces non-productive time.

Further increases in productivity are achieved by providing for three modes of tool retraction at programmer's option. He can retract to the work surface; he can retract to the upper limit (as for tool change); or, he can retract to a clearance plane or selective zero position for clearing obstructions such as clamps or bosses. The NC-223 is the only system offering this multiple choice of retraction as a simple function command.

The NC-223 provides a complete selection of "fixed cycles" to describe the action of the cutting tool for drilling, boring, tapping or milling. Hughes NC-200 Series Controls permit the programming of a complete machine cycle in one block of tape. It is not necessary to program table and spindle commands in separate blocks, nor is it necessary to program out of the hole in a separate block.

Where it is not necessary to hold depth to .001" tolerance, such as in drilling through-holes, the slow-down at the end of a feed motion can be eliminated by the programmer. This permits the tool to travel its entire programmed distance at feed rate, thus reducing total cycle time.

With these distinct features the Hughes NC-200 Series Numerical Controls have closed the gap between engineering drawings and finished production parts; and . . . the manufacturer has gained an extension of management control for improving his competitive position and increasing his operating profits.

# HUGHES

## THE COMPANY

Hughes Aircraft Company is one of the world's largest manufacturers of military and space electronic components and systems. Capabilities and interests range between basic research and development to quality manufacturing, backed up by world-wide field service and technical support.

From the date of the company's inception, Hughes has recognized the increasing demands and importance of lower cost precision manufacturing techniques. Hughes formed the Industrial Systems Division in 1954. The NC-200 Numerical Control System is a product of Hughes advanced engineering know-how resulting from many years experience in the design and development of solid state electronic systems.

### FIELD SERVICE

A staff of highly trained Hughes Field Service representatives are located throughout the world to assist users of the NC-200 Numerical Control System. Complete Operation and Maintenance Manuals are provided with each system; factory-trained service engineers are available for instruction, training programs, and service assistance. These services complete the well-rounded program developed for operating and maintaining NC-200 systems, achieving maximum operating efficiency for the user, and assuring maximum product quality.

Inquiries regarding applications of the NC-200 system and other products of Hughes Industrial Systems Division are invited. Qualified personnel are anxious to help with the simplest or most complex application.

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